Description of the Larva of *Pselaphophus atriventris* (Staphylinidae: Pselaphinae: Pselaphini) with Notes on Its Life History and a List of Described Pselaphine Immature Stages

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Ann. Entomol. Soc. Am. 101(1): 13–19 (2008)

ABSTRACT Approximately 8,900 species of the staphylinid beetle subfamily Pselaphinae have been described, based on adults, but the larvae of only 18 species and 14 genera have been described in sufficient detail for systematic study. The larva of *Pselaphophus atriventris* (Westwood) (Staphylinidae: Pselaphinae: Pselaphini) is described herein based on a series collected in a pasture habitat in New Zealand. Larvae are distinguished from other described larvae of pselaphines based on the following combination of characters: antennal segment two bearing two trifid setiform sensoria and labrum with irregularly arranged short spines and setiferous tubercles. It is most similar to the larva of *Pselaphus heisei* Herbst, sharing the following characters: antenna with two subapical branched sensoria, femora tuberculate, and tibiae with ventral row of minute teeth in proximal one third. *P. atriventris* is introduced to New Zealand and may be widespread in the country in open habitats. Seasonal data indicate that the species is univoltine. Larvae were found during late September–November (early summer), whereas adults are found year-round, but they were most abundant June–December. A list of the described immature stages of Pselaphinae is included.

KEY WORDS Staphylinidae, Pselaphinae, short-winged mold beetles, rove beetles, larval morphology

The subfamily Pselaphinae (Coleoptera: Staphylinidae) is one of the most diverse groups of staphylinoid beetles, with ≈8,900 species, based on adults, and 1,220 genera described (Newton and Chandler 1989, Thayer 2005). But, larvae of a mere 18 species and 14 genera have been described, and significant gaps exist in the representation of these larvae across higher pselaphine taxa. None have been formerly described for the supertribes Faronitae or Bythinoplectitae, and a great many tribes remain unrepresented by larval descriptions. This dearth of information about larval forms is puzzling in view of the ease with which adult pselaphines can be collected using a variety of forest litter extraction techniques. Adults of some of the more common species in a given area and habitat type are often abundant and present during most months, yet collectors may go years without encountering the corresponding larvae.

Work conducted in New Zealand on faunal diversity of pasture habitats by N. Martin during the 1970s (Martin 1983) provided the best data available to date regarding the seasonality of larval development of a pselaphine species. *Pselaphophus atriventris* (Westwood) (Staphylinidae: Pselaphinae: Pselaphini) is an Australian species that was introduced to New Zealand (Klimaszewski et al. 1996, Nomura and Leschen 2006) at some unknown point in history. The genus includes at least five additional named and unnamed species in southeastern Australia (Chandler 2001). During Martin's study, *P. atriventris* was the only pselaphine species identified. Large numbers of adults were collected and pselaphine larvae also were represented in the samples. Because the larva of the species has never been described, we take this opportunity to provide a detailed larval description based on Martin's specimens in the New Zealand Arthropod Collection, Auckland (NZAC). We also discuss the seasonal occurrence of adults and larvae and provide a checklist of descriptions of pselaphine immature stages and related literature published to date.

Materials and Methods

Larval specimens were obtained from pitfall traps in a pasture near Wakefield, Nelson District, New Zealand (41° 28.037 S, 172° 59.870 E; elevation 167 m), August 1971–June 1973. The site was ryegrass and clover pasture at the time (Martin 1983), and it was grazed by cattle and sheep. There was only one species of pselaphine staphylinid collected during the survey, strongly suggesting that the associations of larvae and adults are accurate. Material was preserved in 70%

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0013-8746/08/0013–0019$04.00/0

alcohol after removal from the traps. Material available for study was from a single collecting date with the majority of specimens in poor condition because the tissue and sclerites were relatively soft. Specimens were observed whole or as dissections. Four larvae were decapitated, soaked briefly in KOH for maceration, and the parts transferred to temporary glycerin slide preparations for dissection and examination with a compound microscope.

Larval Material Examined. 25, Parkes' Farm, 88-Valley, Nelson, Grid Reference S20, 369064 (41° 28.037 S, 172° 59.870 E), 9-XI-1971, N. A. Martin.

Associated Adults Examined. Approximately 50, same locality, 2-30-XI-1971.

Mature *Pselaphophus atriventris* (Westwood) Larvae (Figs. 1–10)

Diagnosis. Eversible frontal process rodlike, slightly irregular and frayed near apex. One pair of stemmata present. Antenna two-segmented, segment two bearing two trifid setiform sensoria. Labrum with irregularly arranged short spines and setiferous tubercles. Mala short and rounded. Maxillary palpi three-segmented, segment III elongate with basal seta. Labial palpi 1-segmented. Tibiae with ventral row of minute teeth in proximal one third; narrowed at apical third. Abdominal spiracles present on A1–A6. A9 slightly emarginate apically, urogomphi absent, with three pairs of short setae. Abdominal setae of A8–A9 abruptly narrowed to apices.

Description. *General (Fig. 1).* Length 0.77–1.62 mm (mean 1.19 mm), greatest width (across mesothorax) 0.28–0.52 mm (mean 0.37 mm), head capsule width 0.34–0.38 mm (mean 0.0.35 mm) ($n = 15$). Color of body generally white to yellowish, head capsule and tergal sclerites brown, darker on abdominal segments. Body surfaces generally smooth. Setae simple, straight, elongate on abdomen, with lengths of individual setae approximating maximum body width.

Head (Fig. 2). Rounded. Color of head capsule yellow to brown, lighter along epicranial stem and frontal arms. Epicranial stem long, frontal arms U-shaped to clypeus. One large stemma on each side posterior to antennal insertion. Dorsum of head bearing four pairs of lateral and two pairs of paramedial setae. Eversible frontal process rodlike, slightly irregular and frayed near apex, reaching base of head when fully retracted. Antenna (Fig. 3) three-segmented, inserted laterally; segment I 0.046 mm long, 0.054 wide, glabrous; segment II 0.138 mm long, 0.046 mm wide; minutely granulate on anterior aspect, bearing three setae at midpoint and two trifid setiform sensoria, one attached dorsally and associated with a circular base, the second ventral and more apically located, lacking circular base; segment III minute, 0.023 mm long, 0.023 mm wide, bearing small subterminal and terminal setae. Antennal articulating membrane large but not sclerotized or segment-like. Labrum (Fig. 4) fused with frons; anterior margin gently arcuate, with irregularly arranged short spines and setiferous tubercles except for smooth area at middle; with one pair of long dorsal sublateral setae, one pair of ventrolateral setae, and shorter setae scattered across spinose area; ventrally with a pair of rounded lobes covering most surface either side of midline, each bearing six rounded papillae laterally. Mandibles (Fig. 5) nearly symmetrical, completely enclosed in head capsule when retracted, simple, sickle-shaped, each with a large lateral seta in basal one third; dorsal and ventral cutting edges each bearing three teeth, dorsal edge with larger tooth in anteriormost position and ventral teeth preceded by a cutting edge. Articulation of maxilla (Fig. 6) with head capsule membranous, gula absent. Maxillary cardines short, transverse; stipes elongate, rounded ventrally and prominent, bearing approximately seven setae, mostly near apex and along medial margin, narrowed at palpifer; mala short, rounded, with four setae; maxillary palpi three-segmented, base of palp partially retracted into stipes, segments I and II short, and indistinctly separated, segment III elongate, acute, lacking terminal sensory structures or setae, with basal seta. Mentum and submentum (Fig. 7) not distinct from prementum; labial palpi 1-segmented, narrowly separated and each bearing a single terminal seta.

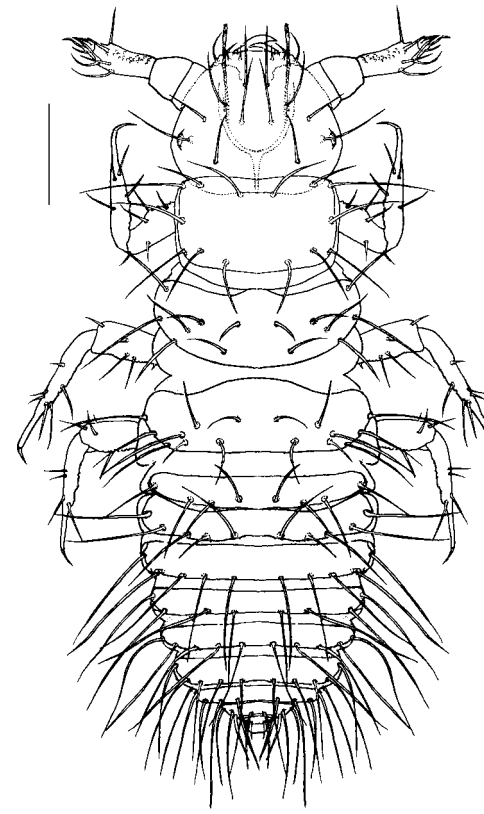
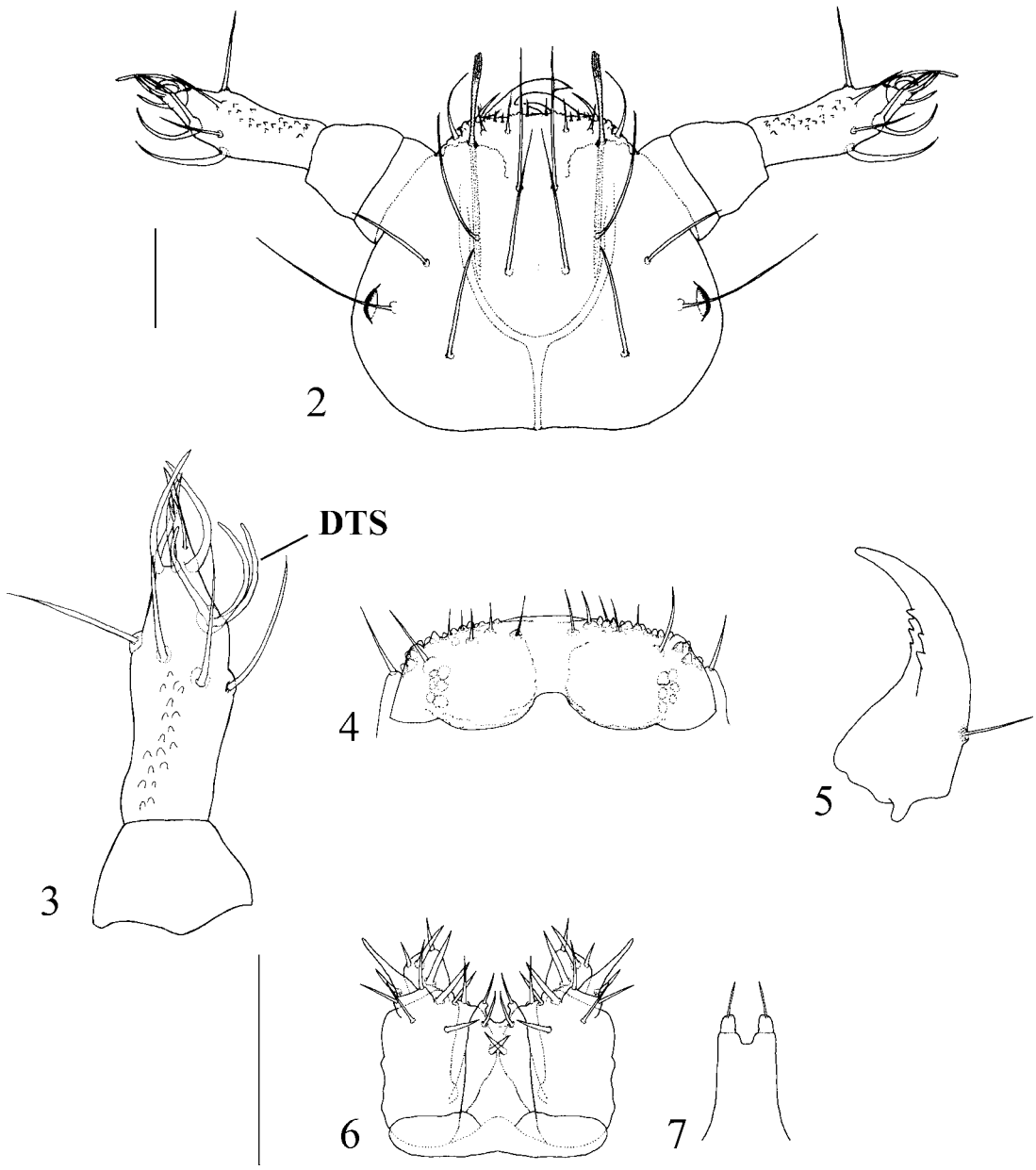


Fig. 1. *P. atriventris* larva, dorsal habitus (scale bar = 0.2 mm).

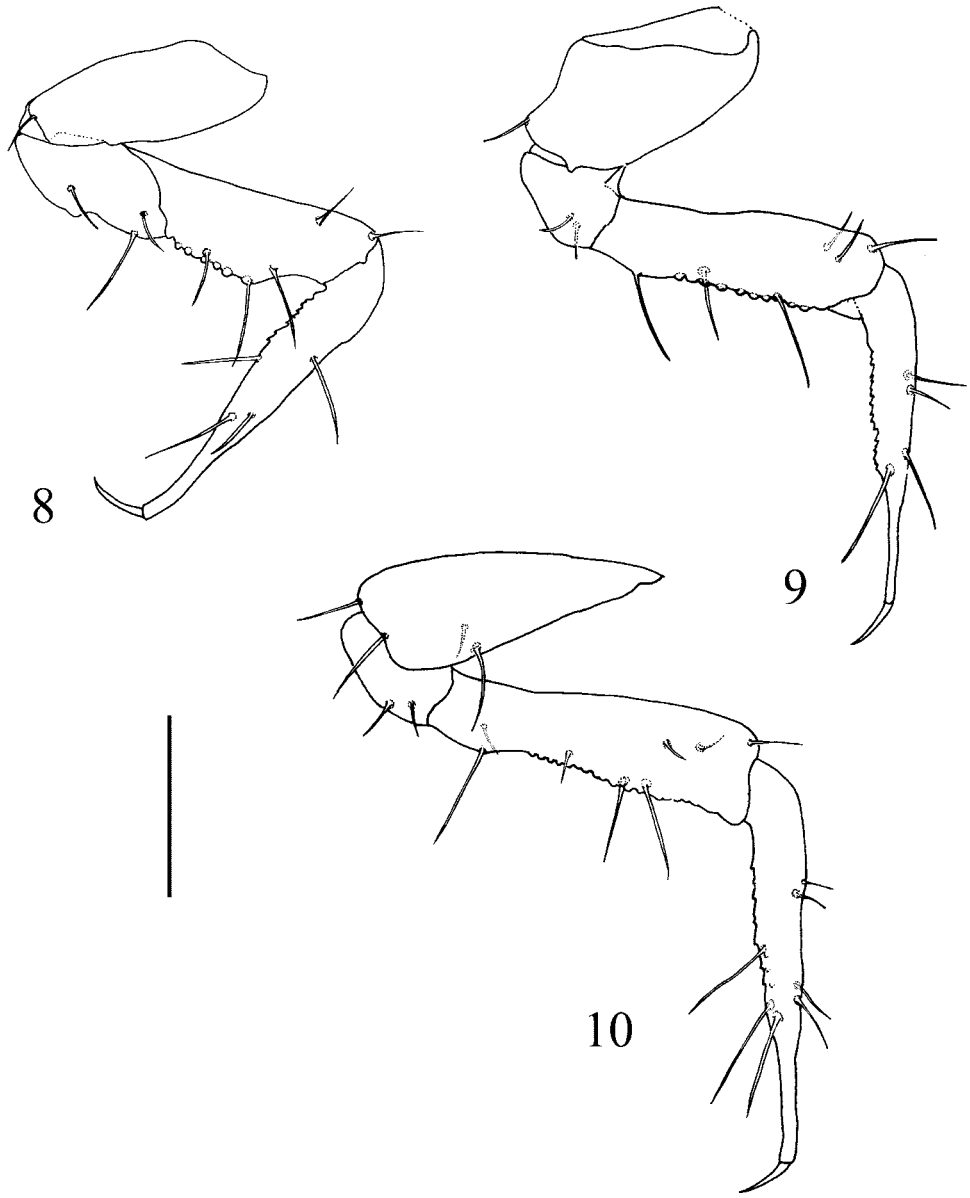
Thorax. Prothoracic tergal plate quadrate, less sclerotized along midline, bearing three pairs of anterior, one pair of lateral, and three pairs of posterior marginal setae; meso and metanotal plates transverse, slightly less sclerotized along midline, evenly rounded



Figs. 2–7. *P. atriventris.* (2) Head; (3) antenna; (4) labrum; (5) right mandible; (6) maxilla; (7) labium (scale bars = 0.1 mm; Fig. 2, top left scale; Figs. 3–7, bottom left scale). DTS, dorsal trifid sensorium.

posteriorly, medially arcuate anteriorly, each with three pairs of lateral and four pairs of discal setae. Thoracic pleura and sterna nonsclerotized, bearing a few minute setae. Coxae transverse. Femora each with six setae, ventral margins of pro- and mesofemora (Figs. 8–9) each bearing a row of ≈11 and eight rounded tubercles, respectively; metafemur (Fig. 10) with a corresponding row of ≈18 smaller, more granular and less regular tubercles. Tibiae with five to seven setae in proximal two thirds; each bearing a ventral row of minute teeth in proximal one third, ≈12 on protibia (Fig. 8), six on mesotibia (Fig. 9), and eight on metatibia (Fig. 10); narrowed at apical one third, asetose in distal one-third of tibiae. Tarsungulus asetose.

Abdomen. Tergal plates narrow transverse, evenly sclerotized, A1 with four pairs marginal setae, A2–A7 with five pairs, those of A3–A7 longer than A1–A2, A8 with five pairs of substantially shorter setae, A9 simple, slightly emarginate, urogomphi absent, apically with three pairs of short setae. Abdominal setae of A8–A9 abruptly narrowed to apices. Spiracles annular, located in membrane just lateral to posterior-lateral corners of terga, present on A1–A6. Ventrites 1–6



Figs. 8–10. *P. atriventris*, legs. (8) Prothoracic; (9) mesothoracic; (10) metathoracic (scale bar = 0.1 mm).

nonsclerotized and bearing only scattered minute setae; ventrites 7 and 8 with lightly sclerotized transverse plates either side of midline; ventrite 9 with undivided sclerotized plate; plates of ventrites 7–9 bearing three pairs of short marginal setae.

Comments. Most of the *P. atriventris* larval specimens available were in poor condition and many characters such as the tormae or other endosclerites of the head could not be examined in slide preparations. The larva of *P. atriventris* can be distinguished from all of the other described pselaphine larvae by the presence of two pairs of trifid sensoria on the second antennomere (one subapical dorsal and the other subapical ventral). Although many pselaphine larvae have appendicular sensoria, they are typically either bifid (e.g., *Bryaxis puncticollis* Denny) or simple (e.g., *Plectophloeus fischeri* Aubé), and may be absent altogether (e.g., *Reichenbachia juncorum* Leach) (Kaupp 1997). *Pselaphus heisei* Herbst has two pairs of multiramous sensoria (five to seven branches), and the presence of multiramous sensoria may separate the Pselaphini from other tribes. *P. heisei* differs from *P. atriventris* in possessing a comb of at least eight primary setae along the posterior margin of segment 9 (De Marzo 1987). One character that has not been mentioned by previous authors is the ventral tubercles on the femora and teeth of the tibiae that are present in *P. heisei* (De Marzo 1987) and *P. atriventris.* Similar structures may

occur in other larvae, and at least in *Batrisodes oculatus* Aubè (De Marzo 1987) tubercle-like structures are present on the proximal tarsus. These are not present in *B. venustus* Reichenbach (Rosenberg 1925).

The identification of the larva of this species is clear because *P. atriventris* is the only species that was collected in the Martin (1983) survey. Species identification was confirmed by the examination of genitalia, which matched illustrations provided by Chandler (2001).

Natural History of *P. atriventris*

P. atriventris is an introduced species in New Zealand (Klimaszewski et al. 1996) with a rather wide distribution in eastern Australia (Chandler 2001). Based on adult specimens in the NZAC, the earliest record for the species in New Zealand is 12 December 1951 from the Nelson region. The range of *P. atriventris* is from Northland (Te Paki) south to Bay of Plenty (Te Araroa) in the North Island and only in Nelson in the South Island. Adults have been collected mainly in pastures, where it is the most common species and was the only species collected in the Martin (1983) survey. One specimen was collected in a Malaise trap set in bush (Poor Nights Island), and another specimen was collected by splashing water on a stream bank (Te Paki). An additional series was collected in a swamp. These data suggest that, although *P. atriventris* may be mainly present in open country, it can occupy a diverse range of habitats.

A thorough study of its seasonality was included in the work by Martin (1983), who surveyed the pasture invertebrates at a single locality in Nelson (Wakefield) for a period of 3 yr and provided important data on *P. atriventris.* Adults were found year-round, but they were most abundant June–December, with peak abundances October–December. Martin suggested that this peak was related to reproductive behavior. Larvae were collected only in late September–November, indicating a single generation per year.

Some of the specimens had guts that were dark and visible on external examination. On dissection, dark brown indeterminate organic matter containing multiple arthropod body parts (e.g., seta-bearing segments, a minute mandible) was observed, confirming that the species is a predator that swallows solid matter (possibly in addition to fluids ingested after extraoral digestion).

Discussion

Potential explanations of the discrepancy between the relative abundance of adult and larval pselaphines have focused on two alternatives. 1) Pselaphine larvae may occupy different microhabitats from the adults. Thus, habitats that yield adult pselaphines are not occupied by larvae at any time of the year. 2) The developmental period for pselaphine larvae is brief with only one or two generations per year, and failure to collect them is a consequence of missing this critical window of larval development. In the few cases of successful rearing of larvae (De Marzo 1986b), no indication was given that specialized conditions or prey items were needed for successful development. Also, methods used in sampling forest litter habitats are broad stroke activities that would likely pick up larvae regardless of how they segregate from adults at the microhabitat scale. Therefore, the first alternative seems unlikely. The study of Martin (1983) supports the second explanation in that he only collected larvae during a brief spring time window while adults were collected throughout the season. Thus, successful collecting and documentation of the life history of pselaphine immature stages may depend on persistent and frequent sampling of pselaphine habitats throughout the year, possibly with special attention to spring if the seasonality of *P. atriventris* is any indication of a general pattern.

Checklist of Described Immature Stages of Pselaphinae

Brown and Crowson (1980) described a possible faronine larva in their article on Scydmaenidae (see Newton 1991).

General Works. Böving and Craighead (1931) (key), Jeannel (1950) (discussion of known larvae to that time), Newton (1991) (descriptions and illustrations), and Newton and Thayer (1995) (phylogeny of Omaliinae group).

Eggs. De Marzo (1986a) (illustrated) and Carlton (1989) (illustrated).

Described or Illustrated Larvae

Euplectitae, Euplectini. *Euplectus* sp., De Marzo (1987), illustrated; *Euplectus confluens* LeConte et al. (1931), illustrated; Wagner (1975), illustrated; *Plectophloeus fischeri* Aubè, Besuchet (1952), illustrated; Kaupp (1997), illustrated; *Pseudozibus crassipes* (Raffray) De Marzo (1987).

Euplectitae, Trichonychini. *Trichonyx sulcicollis* Reichenbach, Besuchet (1956), illustrated.

Euplectitae, Trimiini. *Trimium minimum* Dodero De Marzo (1987).

Batrisitae, Batrisini. *Batrisodes monstrosus* (LeConte), Böving and Craighead (1931), illustrated; *Batrisodes oculatus* Aubè, De Marzo, and Vit (1982), illustrated; De Marzo (1982); De Marzo (1985), histological study; De Marzo (1986b), behavioral study, illustrated; and De Marzo (1987); *Batrisodes venustus* Reichenbach, Rosenberg (1925), illustrated.

Goniaceritae, Brachyglutini. *Brachygluta abrupta* Dodero, De Marzo (1987); *Reichenbachia juncorum* Leach, Kaupp (1997), illustrated.

Goniaceritae, Bythinini. *Bryaxis italicus* Baudi, De Marzo (1987); *Bryaxis puncticollis* Denny, Kaupp (1997); *Tychobythinus glabratus* (Rey) De Marzo (1987).

Pselaphitae, Pselaphini. *Pselaphus heisei* Herbst, De Marzo (1987) and De Marzo (1988a), behavioral study with figures.

Pselaphitae, Tyrini. *Apharus* sp., Costa et al. (1988), illustrated.

Clavigeritae. *Radamopsis bickmanni* Reichensperger, Wasmann (1918), photograph.

Incertae sedis. *Ceroncinus setosus* Silvestri (1920), illustrated, as "Fam.? Lathridiidae," subsequently transferred to Pselaphidae (Kemner 1927); *Euceroncinus quadrimaxillosus* Kemner (1927), illustrated, associated with adults identified by A. Reichensperger as a new genus near *Batrisocenes* Raffray (=*Batrisocenus* Raffray) (Kemner 1927; Newton and Chandler 1989).

Described or Illustrated Pupae and Pupal Chambers

Euplectitae, Euplectini. *Plectophloeus fischeri* Aubé, Besuchet (1956), illustrated; *Euplectus karsteni* Reichenbach, Besuchet (1956), illustrated.

Batrisitae, Batrisini. *Batrisodes oculatus* Aubé, De Marzo (1988b), description and photographs of pupal chamber.

Goniaceritae, Brachyglutini. *Brachygluta abrupta* Dodero; *B. perforata* (Aubé); *Rybaxis longicornis* Leach; *Trisemmus antennatus* (Aubé), De Marzo (1988b), descriptions and photographs of pupal chambers.

Goniaceritae, Bythinini. *Bryaxis italicus* Baudi, De Marzo (1988b), description and photograph of pupal chamber.

Acknowledgments

We thank Nick Martin (Crop and Food Research) for details about *P. atriventris.* This work was funded in part by Foundation for Research and Technology, New Zealand (CO9X0501). Departmental reviews at Louisiana Sate University were provided by V. Bayless, D. Prowell, and A. Tishechkin. C.E.C. thanks Matthew Gimmel for obtaining several items of literature. Donald Chandler provided valuable suggestions and corrections. This article is published with the approval of the Director of the Louisiana Agricultural Experiment Station as manuscript 07-26-0077.

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Received 25 April 2006; accepted 4 August 2007.